What if the ice caps melted?

Introduction

Global warming—a situation in which the Earth’s mean temperature rises over long periods of time—is of great concern today. In this activity, you will examine the potential consequences of an extreme global warming event in which the Antarctica and Greenland ice caps melt.

1. What would happen if the ice caps melted? Speculate on how it would affect our land, economy, and society.

The change in mean sea level

To estimate the change in sea level that would occur if the continental ice caps melted, you will determine the volume of the ice caps and then calculate how that water would change the depth of the oceans.

2. In Activity 1.2, you determined the total volume of water in the ice caps (Table 2, page 9) and the total surface area of the oceans (Table 1, page 7). Write those values below. Include the units.
   a. Volume of water in ice caps =
   b. Surface area of oceans =

If the ice caps were to melt, their water would spread out across the surface of the oceans, raising sea level. The rise in sea level would actually increase the surface area of the oceans as water spread out on to what is presently dry land. To simplify this calculation, however, assume the change in the oceans’ surface area is small enough to be ignored.

3. By how much would sea level rise if the ice caps were to melt?

Effects of the rising sea level

Now that you have a rough estimate of the change in sea level due to the complete melting of the ice caps, you can examine the effects of a sea level rise on global land masses.

   ▶ Launch ArcView and locate and open the gwater.apr file.
   ▶ Open the Melting Ice Caps view.
This view shows the countries of the world and the boundaries of the ocean projected after a 10-meter, 30-meter, and 60-meter rise in sea level. The boundary for the 60-meter rise includes the 30-meter rise and the 10-meter rise.

4. On the map below, indicate the two regions that would experience the greatest flooding from a 60-meter rise in sea level.

![Map showing sea level rise](image)

Use the Zoom In tool to zoom in on the contiguous 48 United States (excluding Alaska and Hawaii).

5. Near which U.S. coast (east or west) would you rather be living if the ice caps were to melt? Why?

- Turn on and activate the US States theme.

6. After a 60-meter sea level rise, which states are completely underwater?

- Choose View Full Extent to view the whole world.
- Turn off the 10-meter Rise, 30-meter Rise, and 60-meter Rise themes and turn on the Affected Population theme.

The Affected Population theme shows the global population living within the region affected by a 60-meter increase in sea level. The theme consists of a number of rectangles, each of which is color-coded according to its population. Areas with fewer than 10,000 inhabitants are not shown.

- Use the Zoom In tool to explore the population data.

7. On which continents will the most people be affected by a 60-meter rise in sea level? How does this compare to your answer for question 4?

- Choose View Full Extent to view the entire map.
Next, you will estimate the total population affected, the total number of cities inundated by floodwaters, and the amount of cropland flooded if sea level were to rise 10, 30, or 60 meters.

**Total flooded area**

Determine the total area flooded for each rise in sea level, starting with the 10-meter Rise theme.

- Turn on and activate the 10-meter Rise theme.
- Click the Open Theme Table button to open the 10-meter Rise theme table.
- Click the Area (km²) field heading. The field name will be highlighted gray to show that it is selected.
- Choose Field Statistics....

In the statistics window, the total area flooded is given as the Sum.

8. Record the total area in the **Total flooded area (km²)** column of Table 1. Round to the nearest 100,000 km².

<table>
<thead>
<tr>
<th>Sea level rise</th>
<th>Total flooded area (km²) to nearest 100,000</th>
<th>Total population affected to nearest 100,000,000</th>
<th>Number of cities flooded</th>
<th>Total cropland flooded (km²) to nearest 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 meters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 meters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 meters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Close the 10-meter Rise theme table.
- Repeat the above steps to find the total area flooded by a 30-meter and 60-meter rise in sea level and record your results in Table 1. Be sure to activate the appropriate theme each time.
- When you are finished, close all theme table windows.

**Affected population**

Next, estimate the affected population in each of the flooded areas.

- Activate the Affected Population theme.
- Choose Theme ▶ Select By Theme....
- Choose from the pop-up menus to make the dialog box read “Select features of active themes that Intersect the selected features of 10-meter Rise (do not select “Cropland, 10-m Rise”), and click the New Set button.

**Rounding**

If you need a refresher on how to round, see the examples on page v.
The densely populated areas that would be flooded by a 10-meter rise in sea level will be highlighted in the map.

- Click the Open Theme Table button to open the Affected Population theme table.
- Click the Population field heading. The field name will be highlighted gray to show that it is selected.
- Choose Field > Statistics....

The total number of people affected by a 10-meter rise in sea level is reported in the statistics window as the Sum.

9. Round the total population affected to the nearest 100,000,000 and record it in Table 1.

- Repeat these steps to determine the total population that would be affected by a 30-meter and 60-meter rise in sea level and record these totals in Table 1. Be sure to choose the appropriate theme in the lower pop-up menu of the Select By Theme dialog box.
- Turn off the Affected Population theme and close all theme table windows.

**Flooded cities**

Next, you will determine the number of cities affected by flooding.

- Turn on and activate the Major Cities theme.

The Major Cities theme includes cities with populations greater than 20,000, capitals, and small but geographically-important towns. The size of the circle represents the size of the city’s population. Determining the total number of cities affected is similar to estimating the affected populations.

- Choose Theme > Select By Theme...
- In the dialog box, set the pop-up menus so that the sentence reads “Select features of active themes that Intersect the selected features of 10-meter Rise.”
- Click the New Set button.
- Click the Open Theme Table button to open the Major Cities theme table.
- Read the number of flooded cities in the status bar.

10. Record the number of cities in Table 1.

- Repeat these steps to determine the number of cities flooded by a 30-meter and 60-meter rise in sea level. Be sure to choose the appropriate theme in the lower pop-up menu of the Select By Theme dialog box.

11. If sea level rose 10 meters, would a major city in your state be flooded? How might this affect you?
- Turn off the Major Cities theme.

**Flooded croplands**

Finally, you will determine the amount of cropland affected by flooding, using a series of themes that show the intersections between the flooding zones and the world’s croplands.

- Turn on and activate the Cropland, 10-m Rise theme.
- Click the Open Theme Table button to open the Cropland, 10-m Rise theme table.
- Click the Area (km²) field heading. The field name will be highlighted gray to show that it is selected.
- Choose Field > Statistics....

The total area of cropland flooded by a 10-meter rise in sea level is given as the Sum.

12. Record the total area of cropland flooded in Table 1. Round to the nearest 100,000 km².

- Close the statistics window.
- Repeat the above steps to find the total area of cropland flooded by a 30-meter and 60-meter rise in sea level. Be sure to turn on and activate the appropriate cropland theme each time.

By themselves, these figures on area, population, and cropland affected by a rise in sea level are somewhat hard to assess. It is useful to compare the figures to the totals for each category and calculate the percentage of land, population, and cropland affected. These totals are given in Table 2 below.

13. Use the totals provided in Table 2 to calculate the percentage affected for each category for a 10-, 30-, and 60-meter rise in sea level and complete Table 3. Round all results to the nearest 1%.

**Calculating percentages**

To calculate percentages for Table 3, divide the value from the corresponding cell in Table 1 by the appropriate total in Table 2, and multiply by 100. For example, for a 10-meter rise in sea level:

\[
\% \text{ Land area affected} = \frac{5,400,000 \text{ km}^2}{147,000,000 \text{ km}^2} \times 100 = 3.67\%
\]

Round to nearest 1% = 4%.
Plotting your results on graphs will help you interpret them. First, you will examine the relationship between the percentage of affected land area and the percentage of affected population.

14. On Graph 1, plot your results for the percent of population affected (on the vertical axis) versus your results for the percent of land area affected (on the horizontal axis). Connect your points with a smooth curve that passes through the origin of the graph (0% land affected, 0% of the population affected).

Graph 1—Effects of sea level rise on population and cropland

15. Plot the percentage of cropland affected versus the percentage of total land area affected on the same graph, using a dashed line. The diagonal line divides the graph into two regions that show the relative strength of the effect of a rising sea level. Points plotted above the line (in the blue region) reflect a greater impact on people and cropland. Points plotted below the line (in the green region) reflect a greater impact on total land area.

16. Which is affected more strongly by a rising sea level, population or land area? What does this tell you about where people tend to live—near coastlines or in the interiors of continents? Explain.
Rising water and global population

The scenarios in this activity are extreme. A global rise in sea level of 1 to 2 meters is a more realistic hazard. You can use your data to construct a graph that will help estimate the effects of such a scenario.

17. On Graph 2, plot the percent of the world's total population affected versus the sea level rise. Connect your points with a smooth curve that passes through the origin of the graph.

Graph 2—Percent of population affected versus sea level rise

18. What percent of the world’s population would be affected by a 2-meter rise in sea level? How about a 5-meter rise?

19. Are these scenarios of flooding a cause for concern? Explain.

Assessing the accuracy of your calculation

At the beginning of this activity, you estimated the rise in sea level due to the melting of the continental ice caps. One of the assumptions you made was that the change in the oceans’ surface area was small enough to ignore. Later, however, you saw that the amount of land covered by the rising sea was quite substantial. In fact, in the 60-meter rise scenario, the amount of land covered by floodwaters is about half the size of the Atlantic Ocean. You can use this knowledge to refine your estimate of the rise in sea level.
20. What is the combined area of the oceans and the 60-meter flood-waters? (Refer to question 2b and Table 1 of this activity.)
   a. Surface area of the oceans =
   b. 60-meter flooded area =
   c. Combined area = (a) + (b) =

21. Calculate the rise in sea level that would occur if the continental ice caps melted completely, by dividing the total volume of water in the ice caps (question 2a in this activity) by the combined area (question 20c). Multiply the result by 1000 to convert from kilometers to meters, and round to the nearest meter.

This estimate for the rise in sea level is a lower limit; your original estimate is an upper limit. The actual rise in sea level would be somewhere between the two.